Integrated Diagnostics
Lessons Learned
F-15 APG-63(v)1 Program

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Overview
F-15 APG-63(v)1 RADAR

- History
  - Requirements
  - Implementation

- USAF Evaluation
  - Metrics
  - Performance

- Lessons Learned

We no Longer have CNDs. We have faults that some are harder to find than others.

Mel Carpenter

RADAR Lead Engineer

**APG-63(V)1**
Radar Langley AFB Briefing
June 2000

Historical Information

SUPPORT SYSTEM
REQUIREMENTS

- SUPPORT SYSTEM ENHANCEMENTS
  - 120 HOUR MTBMA (LRU MINIMIUM OF 500 HOURS MTBD)
    - Reduced Unnecessary Maintenance Actions
    - System is capable of distinguishing between faults and normal operations
    - Provide the Maintainer "POSITIVE ACTION"
  - Reduced "Can Not Duplicates"
    - Capture Parametric Data (Flight and System)
    - Identify "Bad Actors"
    - Testing Verticality
  - Provide Capability to Detect and Isolate 100% of all faults (ID Requirement)
    - Provide Supplemental Testing Procedures to cover BIT Test Voids
    - Identify Aircraft Wiring faults (Detection and Isolation Procedures)
  - Two Level Maintenance

False Alarms
Only 8% of Failure Indications result in Corrective Action

8%
SRU
REPAIR (MTBF)

7%

SRU
RTOK (CND)

SYSTEM
CND

LRU
BCS (CND)

63%

22%
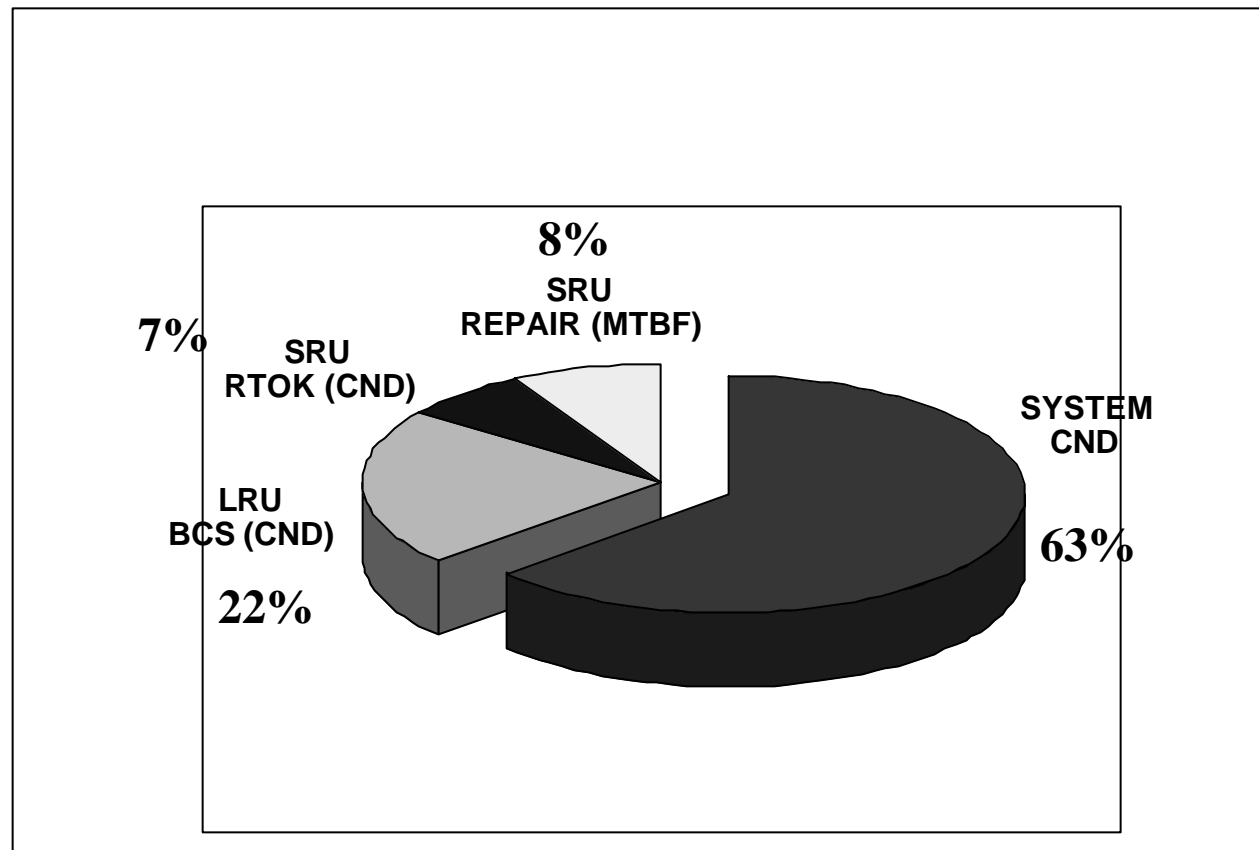
Based on F15 APG-70 Repair data

Form, Fit, Function Lifetime Contractor Support (FLICS)

- Implement F^{3}I
- Guaranteed Availability Rate
- Support peace and war time scenarios
- USAF/Contractor forms partnership for sustainment over the system life cycle
- Affordable cost to USAF
- Must offer Government fall-back position

Guarantee an Availability Rate

Availability $= \dfrac{\text{MTBMA}}{\text{MTBMA+MDT}}$

MTBMA is defined as:

- The average flying hours between maintenance actions

  Where; Maintenance action defined as any effort required to correct a system malfunction

MDT is defined as the maintenance time required:

- Troubleshoot System
- Remove defective LRU
- Obtain serviceable unit
- Install Replacement LRU
- Return the aircraft to operational status

Availability Guarantee
## Things Considered

- System Reliability

- Diagnostic Accuracy and Reliability

- Spares pipeline management and mobility planning
  - Insure proper number of spares at each base, optimize turn around time (TAT), work as IPT to insure aircraft operational readiness

- Mitigate parts/technology availability in real time environment
  - Technology insertion when beneficial

- MTBMA maturation
  - Manage field failure root cause analysis, make MTBMA improvements
  - Adjust diagnostic scheme based on hardware effects and associated aging effects

Availability Guarantee
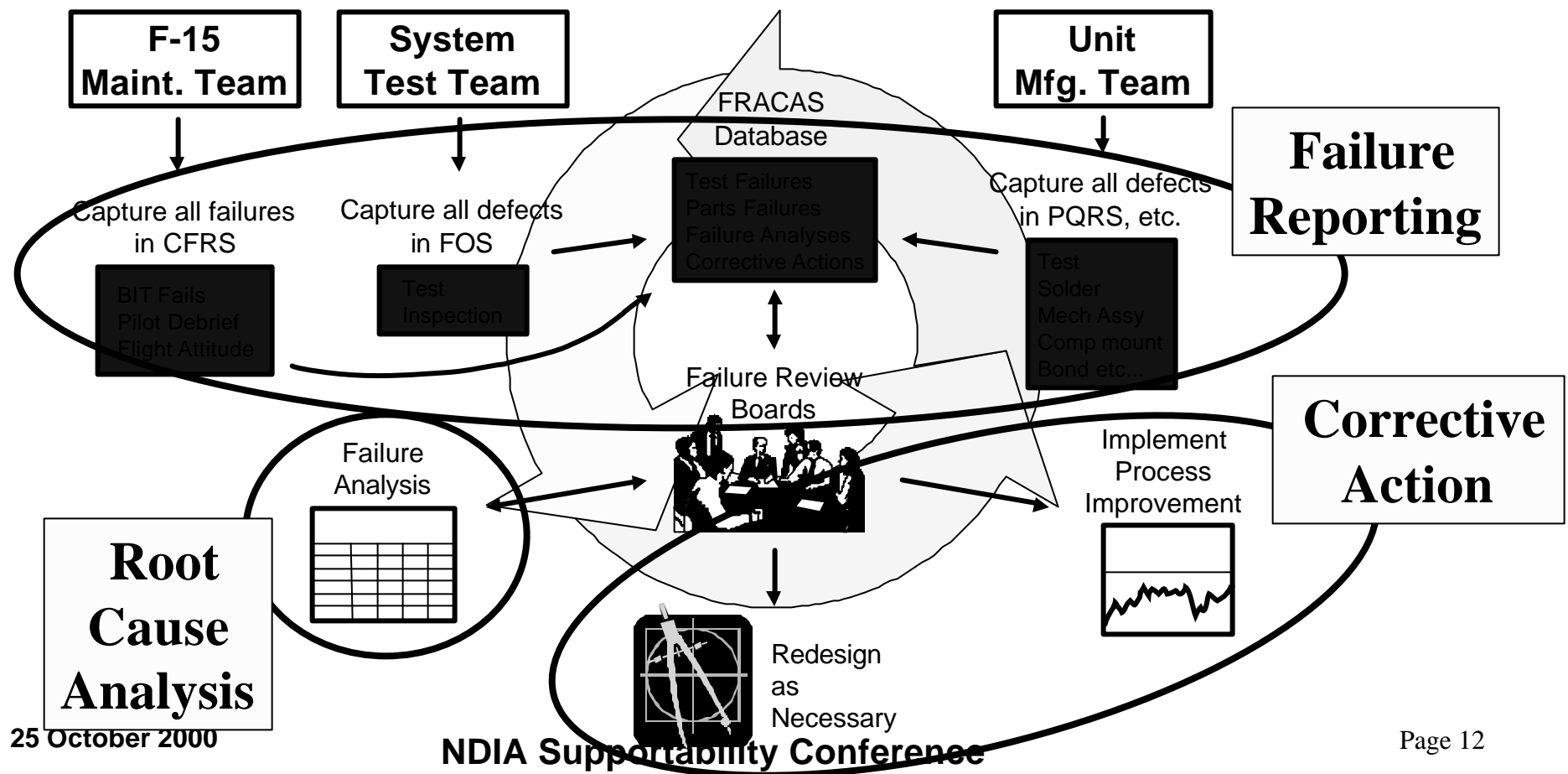## Things Considered

- Proper Maintainer / Pilot Training and Technical Data
  - Tech Pubs updated during EMD
  - CFR/CFI system update; deployment during OT&E
  - All technical information evaluated vs "as designed"
  - Inclusive Diagnostic System at all levels of assembly
  - Single Maintenance Database Source (Wireless LAN Network)

- Automated configuration management required
  - For tracking:

    Base ←→ Aircraft ←→ LRU ←→ SRU ←→ Critical Component

  - Manage parts inventory
  - Tracking of bad actor hardware, remove when necessary

Support System
Implementation

CFR/CFI

Electronic Serial Numbers

DTM

PMA

DEPOT - LRU TESTER

VTTM

DEPOT - SRU TESTER

VTTM
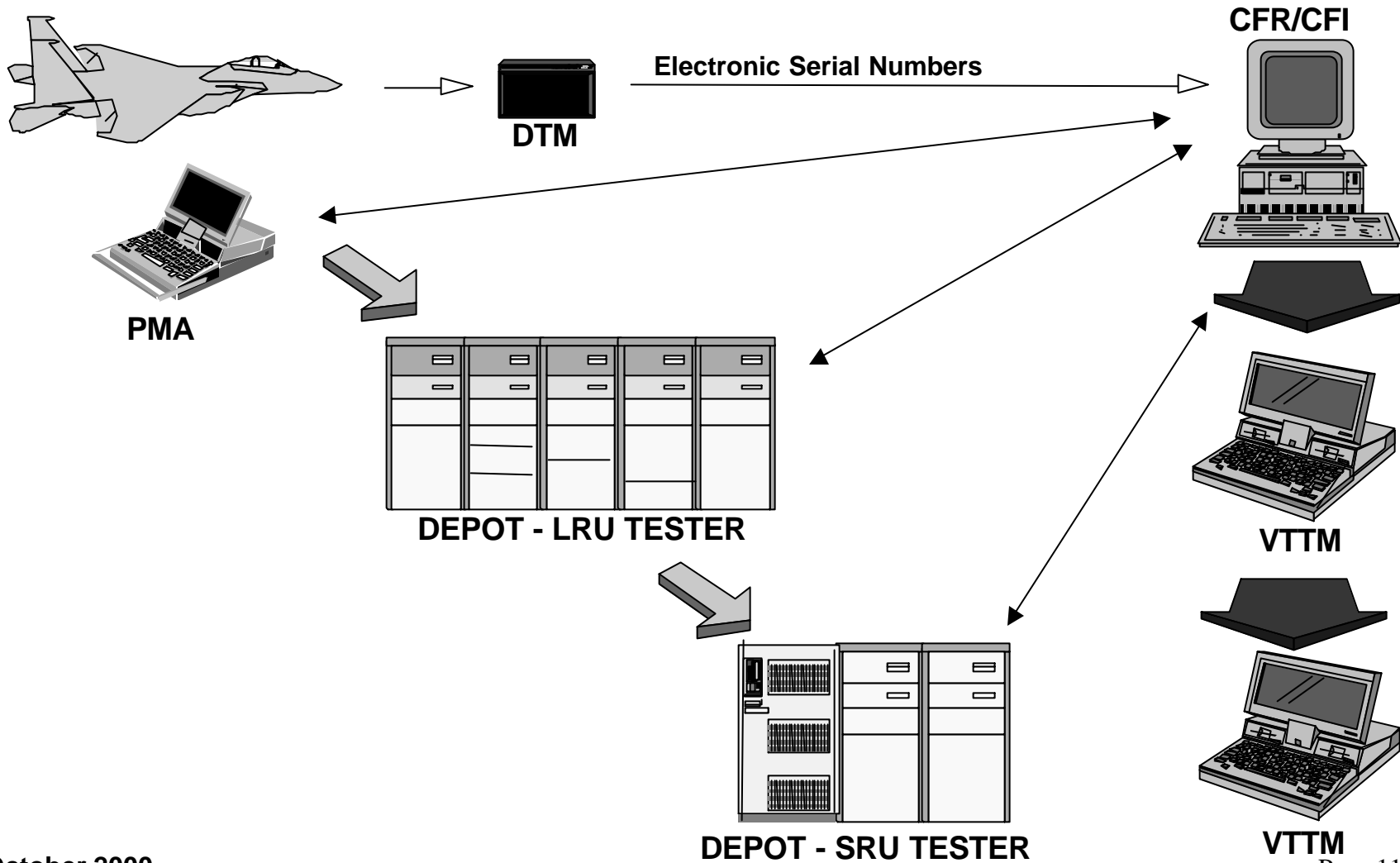
Failure Reporting, Analysis, and Corrective Action System (FRACAS)

- **All failures beyond LRU ESS receive ...**

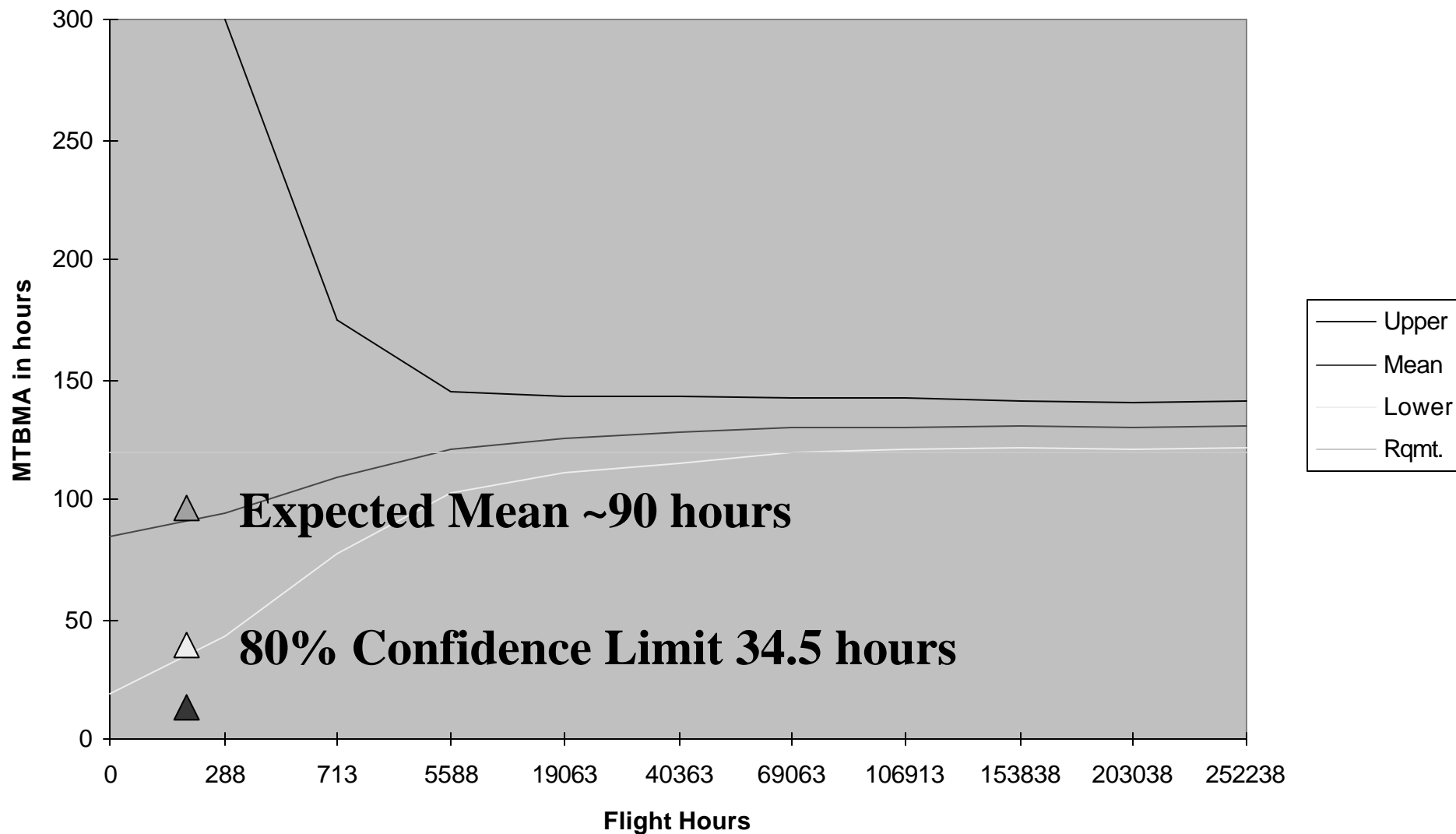| F-15 Maint. Team	System Test Team		Unit Mfg. Team

FRACAS Database

Capture all failures in CFRS

Capture all defects in FOS

Test Failures
Parts Failures
Failure Analyses
Corrective Actions

Capture all defects in PQRS, etc.

Failure Reporting

BIT Fails
Pilot Debrief
Flight Attitude

Test
Inspection

Test
Solder
Mech Assy
Comp mount
Bond etc...

Failure Review Boards

Failure Analysis

Implement Process Improvement

Corrective Action

Root Cause Analysis

Redesign as Necessary

Performance Evaluation
OT&E

AFOTEC

MTBMA Requirement

APG-63(V)1 MTBMA

Expected Mean ~90 hours

80% Confidence Limit 34.5 hours

Diagnostics Performance
OT&E Testing

- Diagnostic System properly diagnosed all 16 failures

  - Built In Test detected 14 failures

  - Supplemental Diagnostics isolated 2 failures

- Number of Can Not Duplicates (BCS) = 1

MTBF and MTBMA Earned Value

- AFOTEC MTBMA = $\dfrac{206.9 \text{ Flight hours}}{16 \text{ Maintenance Events}}$ = **12.9** hours

- "Earned Value" assessment applies verifiable corrective actions (In the "now" condition, the event would have been prevented)

  - **Root Cause and Preventative action taken on 10 Maintenance Events**

  - **Earned Value MTBMA = $\dfrac{206.9 \text{ Flight hours}}{6 \text{ Maintenance Events}}$ = 34.8 hours**

- MTBF_{dc} - based on three (3) true hardware failures = 207/3 = **69.0** hours

  - The three components that failed have proven high reliability (pressure switch, 91K hours; switch filter, 143K hours; and tone modulator, 37K hours)

  - These failures during IOT&E are most likely random part failures

What Happened?

- OEM Manufacturing & OEM Depot changed location
  - Remaining parts in parts bin used to build last units from El Segundo
  - Manufacturing learning curve (corporate knowledge / unique skills)

- Man in the Loop
  - Diagnostic Data capture not fully automated
    - Data captured 30% of the time
  - Evaluation site negated need for PMA at plane-side

- Training
  - Rotations resulted in Maintainers unfamiliar with RADAR & Support Concept
  - System used outside its designed capability

- Maintenance Data Collection System Infra-Structure woefully lacking
  - Not a staffed position
  - Lack of Hardware / Software configuration control
  - System capability varies from squadron to squadron

Lessons Learned

- Automate the data collection process
  - Eliminate as much human interface as possible
  - Should be invisible to operator

- Maintenance Data at Depot is vital to effective repairs
  - Data collected needs to be detailed enough to duplicate failure at Depot

- Training
  - Provide Detailed Information on operating modes
    - Proper utilization / expectations
    - Identify normal operation under different environmental conditions

- Applying a new Support System to Legacy Aircraft meets resistance
  - Customer support from Top to Bottom is essential

Questions ???